The mycorhiza of forest trees.—Some important experiments have been carried on by JOSEF FUCHS[17] with the mycorhiza of forest trees. The chief object of the experiments was the synthetic production of mycorhizas by bringing together pure cultures of the two symbionts. The trees employed were various conifers, and the fungi consisted of a number of humus-inhabiting forms. Most of the experiments gave negative results, but when six-month seedlings of *Pinus Strobus* were brought into contact with cultures of *Collybia macroura*, a strong development of endotrophic mycorhiza was secured. The finding in certain cultures of spores and mycelia quite unlike those used in the inoculations caused FUCHS to believe that root infection often may come from the seeds rather than from the substratum. *Picea* seedlings eight days old growing in sterilized humus had their roots infected by fungi. The infected cells of the conifer roots soon turned brown and were cast off, suggesting that the fungi are truly parasitic and not beneficial to the conifers. Frequently the invading fungi are deformed and killed by the protoplasm of the root. These results were obtained both with ectotrophic and with endotrophic mycorhizas.

W. B. MCDOUGALL[18] has made a careful study of the mycorhizas of a number of our common American trees, chiefly angiospermous species. Various forms of ectotrophic and endotrophic mycorhizas are described, both sorts being found on the same root in *Tilia americana.* In some cases the fungus species involved were identified, and it was observed that the mycelia of different species frequently can be distinguished from one another by differences in color and structure. Observations made at all seasons showed that mycorhizas are much more in evidence in autumn, winter, and spring than in summer, and hence are usually annual. The fungal symbiont in ectotrophic mycorhizas, so far as known, is almost always a basidiomycete, whereas this is rarely the case with endotrophic mycorhizas. Some mycorhiza fungi can inhabit several hosts and the host trees also may have several different mycorhiza fungi, but all mycorhizal fungi cannot form mycorhizas on all mycorhizal trees. Individual trees or parts of trees are often without root fungi, probably because the proper fungus species happens to be absent. The development of the mycelial mantle in the ectotrophic mycorhizas checks further root growth, whereupon branching takes place, resulting in the characteristic coralloid aspect of the small root branches. The author in discussing the theories of previous workers agrees with FUCHS (though not quoting him) that the fungi of ectrotrophic mycorhizas are ordinary parasites; these fungi are of no value to the trees, nor are they probably very harmful, since so many roots are without them, especially in the deeper soil layers. MCDOUGALL is less confident concerning the

[17] FUCHS, JOSEF, Über die Beziehungen von Agaricineen und anderen humusbewohnenden Pilzen zur Mycorhizenbildung der Waldbäume. Bibl. Bot. no. 76. pp. 32. *pls. 4.* 1911.

[18] MCDOUGALL, W. B., On the mycorhizas of forest trees. Amer. Jour. Bot. 1:51–74. *pls. 4. fig. 1.* 1914.

rôle of the fungi in endotrophic mycorhizas, as in *Acer*. The only adverse criticism to be made of this excellent paper concerns the mere detail of the use of the words symbiosis and heterotrophic. Heterotrophic is used for the case (*Tilia*) where the same root has ectotrophic and endotrophic mycorhizas, which certainly is not the usual sense of the word. Both McDOUGALL and FUCHS contrast parasitism and symbiosis, whereas etymology and the best usage make parasitism a kind of symbiosis.—H. C. COWLES.

Photo-growth reaction.—BLAAUW,[19] who has already proved himself a master in phototropism, now publishes an excellent piece of work on the effect of illumination on the growth of the sporangiophore of *Phycomyces*. He uses the term "photo-growth reaction" to indicate the changes in growth rate and amount caused by a single short application of light. He first works with equilateral illumination applied at right angles to the organ from four or eight directions. The quantity of illumination in the different experiments varies from 1 to 7,680,000 M.K.S. In all cases an early acceleration in growth is followed by a later retardation. In illumination of 16 M.K.S. and above the acceleration begins about 3.5 minutes after the beginning of illumination. In 1 M.K.S. it begins after 8 minutes, and in 6 M.K.S. after 6 minutes. The maximum acceleration was at about 7 minutes in 16 M.K.S. and above and later in lower quantities. Then follows a gradual fall in growth rate until a rate considerably below the normal is reached, and then a gradual rise until the normal rate is again reached. The duration, amount, and overlapping of these reactions vary much with the amount of illumination. In some of the lower light amounts the total acceleration exceeds the total retardation by threefold, while in the higher amounts the latter exceeds the former. This agrees with the finding of JACOBI that slight illumination (low intensities of medium duration or high intensities of short duration) accelerate growth, while medium or great amounts of illumination retard growth. JACOBI deals with only the difference of the accelerating and retarding effects, since she took her readings 24 hours after exposure. BLAAUW'S work gives the continuous curves. In all the older works only the retarding effect had been reported. BLAAUW finds that for low light quantities, where the accelerating does not overlap the retarding effect, a quantitative relation can be found between quantity of stimulus and quantity of acceleration. The increased growth is proportional to the cube root of the light amount. JACOBI'S conclusion that the quantity of stimulus law does not apply here is due to her failure to recognize that both effects (accelerating and retarding) appeared in every application, and that she was dealing only with their difference.

In a second group of experiments BLAAUW deals with phototropic response in the same organ, and with good evidence comes to the conclusion that phototropism in this form can be explained entirely by the total of the "photogrowth reactions." This brings us back to the old view of DE CANDOLLE under

[19] BLAAUW, A. H., Licht und Wachstum I. Zeitsch. Bot. 6:641–703. 1914.